Research Note 85-9

PLACEMENT MODEL IMPLEMENTATION PLAN FOR TOW WEAPON SYSTEM TRAINING

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Gunner training programs for the TOW antiarmor weapon system could be improved in terms of cost effectiveness by implementing appropriate candidate selection models. Candidate gunner selection factors lend themselves to cost per graduate/dropout/failure analyses as well as to program wide efficiency. A review of related literature and the background problems with TOW gunnery training is presented. The alternative models address cost in terms of attrition vs. graduating gunners for Army wide support.

FOREWORD

This report is one of a series on the research support provided by the Mellonics Systems Development Division of Litton Systems, Inc., to the Army Research Institute for the Behavioral and Social Sciences (ARI) under Contract Number DAHC 19-77-C-0011. The report, as submitted, is a part of the final report of the total contractual support effort; it will be incorporated into that report by reference.

As set forth in the Contract Statement of Work, the Mellonics effort includes support to the Training Effectiveness Analysis (TEA) program, a research effort focusing on the analysis of training effectiveness for each of three weapon systems: M16A1 Rifle, TOW, and Dragon. This report reviews currently available literature on TOW training to determine points in the training system where placement model measurements could be cost-effectively implemented, and presents an optimal plan.

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PLACEMENT MODEL IMPLEMENTATION PLAN FOR TOW WEAPON SYSTEM TRAINING

OBJECTIVES: Review the currently available literature on TOW training to determine points in the training system where placement model measurements could be cost-effectively implemented. Of the alternatives identified in the first objective, select a cost-effective, optimal alternative providing particular rationales for decisions used in its selection.

TASKS:

a. Review currently available literature produced from other TOW related contracts, the current Resident Contract, and ARI in-house work and identify/present alternative cost-effective plans for placement model implementation.

b. Prescribe cost versus effectiveness trade-offs for each alternative.

c. Identify and present the most cost-effective or otherwise optimal plan.

d. Describe, in detail, the rationales for selecting the optimal plan.

PROBLEM: Given a predictive model prescribing multiple, measurable variables which, when applied, will identify Army personnel who are not fully qualified to undertake TOW weapon system training, determine the optimal, cost-effective alternative for model implementation.

BACKGROUND: Since the introduction of the TOW weapon system in 1970 the Army has been attempting to establish a standardized selection model which could be applied to potential TOW system trainees, and which would predict, with a high degree of assurance, their training proficiency. To date, no criteria have been identified which fully meet this requirement. ARI has developed a placement model which considers certain physical, mental and performance variables as possible indicators in determining whether or not an individual should be considered for TOW training. The model is essentially a "selection-out" procedure which is predictive in nature and identifies measurements known to have a positive correlation to effective TOW training. The basic objective of the placement model is to identify personnel who do not hold the potential for satisfactory performance as TOW gunners. Such an identification procedure could have a positive impact upon cost-effective training at the institutional level as well as in inidividual TOW training conducted by field units.

It is envisioned that the ARI placement model could assist in reducing the attrition rate in TOW gunnery qualification training, thus affecting a savings in cost per graduate dollars and in overall training time efficiency. In order to effectively apply the placement model, however, costs associated with the measurement of certain variables associated with model application must be identified. In addition, the appropriate level for the model's application must also be established.

ASSUMPTIONS: Certain fundamental assumptions are postulated in this research effort in order to establish validity and to recognize "real-world" constraints

related to Army field operations and the resource limitations associated with this paper:

- The Army's annual requirement for qualified TOW gunners trained at the institutional level will remain relatively constant through FY 1981.

- The physical and mental qualification requirements for Military Occupational Specialty (MOS) 11B (Infantryman) and the future MOS11H (TOW Antiarmor Crewman) will remain essentially the same.

- Direct costs associated with Procurement Appropriation (Army) for acquisition and fielding of TOW weapons and related equipment will remain constant through FY 1981.

- The establishment of One Station Unit Training (OSUT) for Infantry personnel will have no significant impact upon implementation of the ARI placement model.

- The "commander's evaluation", currently administered during Advanced Individual Training (AIT), and used as a primary pre-selection criterion, will continue to be a requirement for selection of personnel to attend TOW gunnery training.

LITERATURE SEARCH: A review of currently available literature produced from TOW system research efforts associated with the ARI-Litton Mellonics Resident Contract, ARI in-house TOW training studies and investigations, and the Litton Command Studies Contract, revealed information only marginally relevant to this specific study effort (see Annex A for references). The Litton final report: "Implementation for TOW Gunnery Training Development"[1] has identified serious shortcomings in the Army's ability to correctly predict the proficiency of TOW gunnery trainees due to a lack of pre-selection criteria. The study suggests the possible use of such variables as dominant eye, finger dexterity and M-70 tracking performance scores in determining pre-selection gunnery training criteria. This study also lists certain pertinent cost factors associated with the TOW gunnery training program conducted at the U. S. Army Infantry School, Fort Benning, Georgia. TRADOC's A^2S^2 study clearly identifies a gunner profile indicating those traits, abilities and attitudes thought necessary to successful TOW gunnery proficiency. However, the study also emphasizes that insufficient research has been conducted which would determine the extent of a valid causal relationship between "desired qualities and the correlated traits/abilities/attitudes on the gunner profile...." Pre-selection criteria, and a reliable standard for measurement of these criteria, remain to be determined.[2] The U. S. Army Infantry School's TOW System Evaluation study has identified a single variable which might be predictively used in the trainee

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[1] Swezey, Chitwood, Easley and Waite, Implications for TOW Gunnery Training Development, Litton Mellonics, Springfield, Virginia, October 1977, pgs. 91-92.

[2] U.S. Army Training and Doctrine Command, Anti-Armor System Study (A^2S^2) (Final Report) (U), U. S. Army Training and Doctrine Command, Fort Monroe, Virginia, December, 1976 (CONFIDENTIAL), pgs. C-6, C-7.

selection process and at the same time accommodate the desire to "allow as much latitude to the Commander and personnel managers as possible." The most efficient gunner selection criterion was determined to be the General Maintenance Aptitude test score as measured on the Army Classification Battery, (ACB 73) test. This measurement appears to indicate, based upon a cut-off score of 99, a positive correlation with increased gunnery qualification rates using the M-70 training set.[3]

The absence of pertinent confirmatory literature and valid study efforts on the subject of TOW training selection criteria highlights the current research effort and contributes in no small measure to the urgency in attempts to establish a valid, cost-efficient placement model.

MEASURES OF EFFECTIVENESS (MOE): The relationship which exists between resources consumed (costs) and output (productivity) concerning a given activity determines the efficiency of that activity. The fewer resources consumed in producing a measurable unit of output, the more efficient the activity is thought to be. A given activity within the Army such as the entire training establishment, a particular institutional or unit training program, or a single course of instruction within an overall training program can be classified as a productive entity. Most activities such as a program of instruction consume resources such as dollars, manpower and equipment, and provide output consisting of trained personnel which form the aggregate trained strength of the Army.

Of the several productive training activities within the Army, the current analysis is concerned with individual skill training. The primary objective of individual training programs for Army personnel is to produce knowledgeable, disciplined service members who are capable of effective operation in the Army job structure and who contribute positively to the combat capability and mission readiness of a given Army unit. The ultimate measure of effectiveness is combat success. In the absence of a combat environment, training effectiveness must be relied upon as the most dependable measure of effectiveness.

Although there exist a number of possible ways to measure the effectiveness of a training program, it is generally agreed that attrition rates can be used to furnish one efficiency measure. Student-to-instructor ratios provide useful information, but fail to accurately account for the effects of variance in either course length or attrition rates. Other primary factors such as support costs, skill retention rates and other variable costs also remain unaccounted for in the staffing ratio analysis measure. In order to more fully account for the efficiency of a given training program all possible costs must be accounted for as well as provide for the measurement of a standard unit of output.

One promising measure of efficiency, though not fully validated at this time, is the cost per graduate of a given training program. This measure provides training managers and decision makers with a valuable tool for total management of a training system. It must be emphasized that this measure should not be relied upon singularly to account for or evaluate the effectiveness of aggregations of training programs. The utility of this MOE is expressed clearly in the Military Manpower Training Report for FY 1978, prepared by the Office of the Assistant Secretary of Defense (Manpower and Reserve Affairs):[4]

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[3]U.S. Army Infantry School, <u>TOW System Evaluation, DEV Report No. 3</u>, U.S. Army Infantry School, Fort Benning, Georgia, December, 1976, pgs. 34-43.

Training output may be thought of in terms of the pattern of skills a given number of students learn or the amount of knowledge they gain. But skills and knowledge are difficult things to define and quantify precisely. On the other hand, the number of students who graduate from a course is an easily defined and readily available piece of information that can be meaningful.

If there are established criteria for graduation, then graduates provide a useful gauge of training output. One graduate of a particular course may obviously learn more than another graduate of the same course, but both at least meet some established criteria -- examinations, practical tests or other demonstrations of acquired skills -- for graduation. (A separate question -- and one that transcends the efficiency of training -- is whether the criteria for graduation are properly linked to the skills required by graduates when they reach their jobs. To the extent that the linkage is faulty, the effectiveness of military training is considered to have suffered...)

To the extent that established graduation criteria actually measure the learning, then the production of a graduate indicates that a training program has produced at least some specific amount of output. Hence, the resources required to produce a graduate can be used as a measure of training efficiency.

Cost per graduate can tell a manager how much it costs to train one infantryman, one dental technician, or one automotive mechanic. It can tell a manager how much it costs to turn out one soldier, sailor, marine, or airman from recruit training. More importantly, changes in cost per graduate can highlight for a manager which courses appear to be improving in efficiency and which courses he should take a closer look at to find explanations for possible decreasing efficiency. Using standard cost-accounting systems a manager can compare the efficiency of the same training conducted on various installations or by different commands under his purview.

As a sub-function of cost per graduate for a training program, the rate of attrition for that program must be given careful consideration. It should be noted at the outset, however, that a high attrition rate for some training programs may not necessarily point to a failure in the training establishment per se. Attrition can be attributed to poor teaching, but it can also be traced to poor students as well. The quality of enlistees in the Army impacts directly upon training program attrition rates. Attrition rates in themselves can be viewed as useful indicators for management. For instance, a high attrition rate

[4] Office of the Assistant Secretary of Defense (Manpower and Reserve Affairs), Military Manpower Training Report for FY 1978, OASD (M&RA) Washington, D. C. March 1977, pg. 7.

may be caused by a failure to provide sufficient additional or remedial instruction to marginal students. A high attrition rate in a course such as TOW gunnery training could also mean poor instruction or that criteria for acceptance into the training course need to be revised or strengthened. See Annex B for a detailed discussion of Attrition and Course Length.

For purposes associated with this analysis two MOEs will be considered:

- o Cost per graduate

- o Attrition rate per course

CURRENT INDIVIDUAL ARMY SKILL TRAINING PROCEDURES:

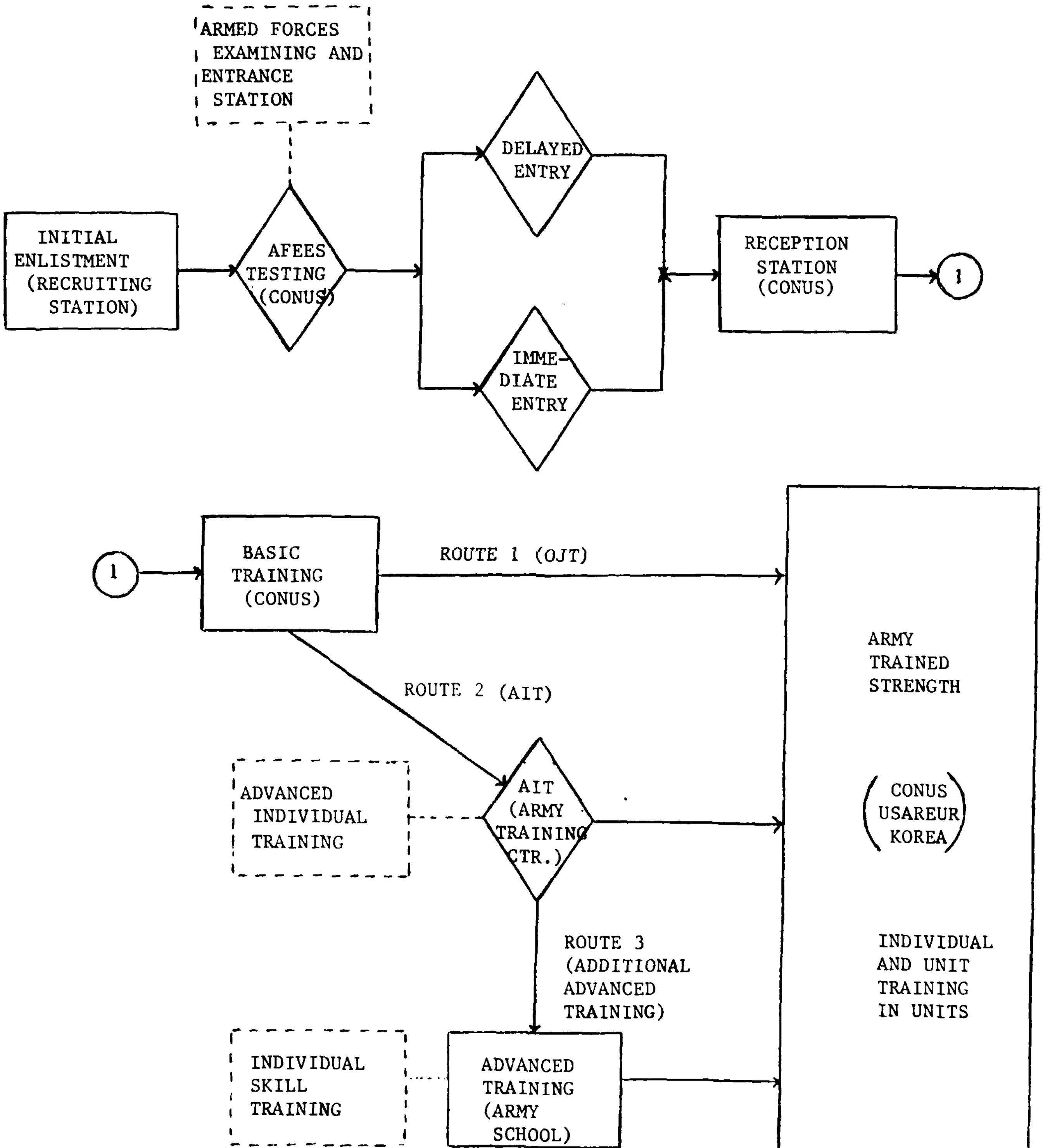
Service Entry Procedures. Army enlistees currently follow a well defined, regimented procedure from initial entry into the service through the final stages of advanced individual skill training. Follow-on individual training such as TOW gunnery training is provided to certain numbers of pre-designated personnel based primarily upon the Army's annual requirement for TOW gunners and upon a subjective selection process known as the "commander's evaluation." Table 1 shows a flow diagram of the initial entry procedures for Army enlistees and also prescribes initial Army skill training.

After enlistment, an individual will be directed to report to one of 66 Armed Forces Entrance and Examining Stations (AFEES) located throughout the United States. At the AFEES station, or at locations adjacent to AFEES stations, the enlistee is administered a complete physical examination and is given a comprehensive battery of tests (pencil and paper) to determine his aptitudes within the Army Military Occupational Specialty (MOS) program. The average enlistee spends approximately 8 hours at an AFEES. If the enlistee is determined to be physically and mentally fit for service he will be assigned a specific MOS identifier in accordance with his enlistment contract and his aptitudinal qualifications. Also at the AFEES, if qualified, the enlistee may elect to delay his entry into the service for a period up to 365 days. Upon termination of the delayed entry time period the enlistee will return to the AFEES and receive a modified physical examination to ensure his continued physical qualification for service entry.

From the AFEES the enlistee will proceed to an Army Reception Station which is collocated with an Army Training Center (7 locations in CONUS). Here the new soldier is counseled as to military life at his new station, receives a records check, haircut and an initial issue of military clothing. The average time spent at a Reception Station is 4 days. The enlistee then proceeds to a basic training unit on the post and remains in basic training for eight weeks. At the completion of basic training he may proceed directly to a field Army unit for on-the-job (individual) training (OJT) or he may move to an advanced individual training (AIT) unit and receive advanced individual skill training prior to field unit assignment. AIT training is normally eight weeks in duration. One station unit training (OSUT), now being instituted for most basic and advanced individual skill training in the Army, will modify the length of time spent in basic and advanced individual training and an overall average of 12 weeks. However, OSUT training for infantry trainees (MOS11B) has not yet been instituted. Additional advanced individual skill training such as TOW gunnery training may be provided to selected trainees following AIT. This training is followed, as in the earlier two examples, by ultimate assignment to an Army

Table 1

INITIAL ENTRY AND SKILL TRAINING



field unit in CONUS or overseas. In all three cases, assuming graduation from the training course, an enlistee is awarded an MOS. Additional skill indicators (ASIs) are awarded to graduates of advanced skill courses such as TOW gunnery.

MOS Qualification. In the example of a combat arms soldier, the Infantrymans' MOS11B is awarded after completion of advanced individual training either in a field unit or after completion of AIT. Change 4 to Army Regulation (AR) 611-201 states that the basic qualifications for MOS11 - Maneuver, Combat-Arms (including MOS11B) are:[5]

- o Ability for effective oral communication
- o Reasoning ability
- o Recall of detailed instructions
- o Number facility
- o High emotional stability
- o Physical stamina, agility, endurance
- o Hearing acuity
- o Good night vision
- o Depth perception
- o Clarity of speech
- o Awareness of the importance of effective interpersonal relations and teamwork

Upon the award of MOS11B an individual trainee may be selected, depending upon his capabilities and aptitudes, to attend additional individual skill training at the institutional level or within his assigned unit. One course of instruction representative of this special individual skill training is the TOW gunnery course currently being conducted at Fort Benning, Georgia.

Selection Criteria, TOW Gunnery Course, Fort Benning, Georgia. During the final weeks of AIT training an 11B trainee may be considered for attendance at the TOW gunnery course depending upon the following criteria:

- o Overall Army requirements for TOW gunners (1,500 per year FY 78-81).[6]
- o Commander's subjective evaluation of trainee
- o Course capacity

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[5]Department of the Army, C4, AR 611-201 Personnel Selection and Classification, Enlisted Career Management Fields and Military Occupational Specialties, Hq., Department of the Army, Washington, D. C., 9 June 1975, pg. 3-11-3.

The commander's subjective evaluation consists of a value judgement as to whether or not a potential TOW gunnery trainee has (or is):

- a positive attitude
- high agility
- good dexterity
- good physical fitness
- not over six feet tall
- Sharpshooter or Expert on the M16A1 rifle
- meets the overall needs of the Army
- good disciplinary record

Current Attrition Rates. No other pre-selection criteria are applied to trainees being considered for TOW gunnery training. Thus, no validated gunnery proficiency predictors are available. As a result, attrition rates at the Fort Benning course between the period 14 October 1976 and 5 May 1977 averaged 26.25%.[7] For the period 3 February 1977 - 5 May 1977, however, the average attrition rate was reduced to approximately 12% per class due to course content program changes representing improved instructional techniques. The current cost per trainee in the Fort Benning, Georgia, TOW gunnery course is $658. After applying the 12% attrition rate, the cost per trainee jumps to $747 per person.[8] Tables 2 and 3 show estimated attrition rates/dollar losses and current dollar costs per TOW trainee respectively.

There is no completely reliable scientific method available for identifying how much of the current average 12% TOW gunnery training attrition rate is directly attributable to unsatisfactory pre-selection criteria. As previously asserted, attrition of trainees can be caused by illness, poor instruction, insufficient instructor/student ratios, etc. It is reasonable to assume, however, that some portion of the attrition rate can be attributed to the absence of objective, pre-selection criteria. Identification of variables to be measured, establishment of procedures for the measurement of variables, and validation of the applicable variables appear to be legitimate objectives if the effectiveness of TOW gunnery training is to be increased.

ARI SELECTION PLACEMENT MODEL:

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[6] Information furnished by Department of the Army, Deputy Chief of Staff for Personnel, 8 November 1977.

[7] Data supplied by U.S. Army Infantry School, Fort Benning, Georgia (Weapons Department).

[8] Data furnished by U.S. Army Infantry School, Fort Benning, Georgia.

Table 2

ESTIMATED ANNUAL TOW GUNNERY TRAINEE

ATTRITION AND DOLLAR LOSS FY 1978-81

FY	Trainee Attrition	Dollar loss
1978	180	118,440
1979	180	118,440
1980	180	118,440
1981	180	118,440
4 Year Total	720	$473,760

Notes:

(1) Estimated cost per trainee graduate is $737 at 12% attrition rate (inflated 1977 dollars).
(2) 1500 annual trainee graduates required.

Table 3

COSTS PER TOW GUNNERY TRAINEE

Direct Costs	Operations and Maintenance Appropriation (Army) $	Military Personnel Appropriation (Army) $	Procurement Appropriation (Army) $
Mission Costs (Instructor Department)	29	73	
Ammunition			95
Equipment Item Depr			5
Trainee P&A		210	
Subtotal	29	283	100
Indirect Costs			
Base Operations	146	53	
Support Costs			
Training Aids	5	1	
Other	24	19	
Subtotal	173	73	
Total/Trainee	$658		

Note: Based on FY 77 inflated dollars; 5 day training course, 44 hours in length.

(From: Final Report, Implications for TOW Gunnery Training Development, Litton Mellonics, Springfield, Virginia, 1977, pg. 126.)

Model Description. ARI has developed a model which is predictive in nature as to the probable proficiency of potential TOW gunnery trainees. The model is essentially a tool for identification of certain variables (mental and physical characteristics) which can be relied upon to "select-out" those personnel in the MOS11B category who do not possess attributes predetermined to be necessary for proficient TOW gunners (see Table 4).

As prescribed, the model lists discriminant variables which are easily obtained from the enlistee's DA Form 20 and medical records, can be readily recorded in the field by direct observation, question and answer, or simple measurement; and can be relied upon to discriminate by accurately predicting proficiency in future training. Two variations of the model are contemplated for application at various levels in the Army enlistee processing system:

- MOV - (visual, physical variables plus the discriminant performance variable of M-70 tracking scores at 5 and 25 milliradians per second)

- O - (visual and physical variables only)

Table 5 shows the variables contained in the MVO and O models and the estimated time and cost for obtaining these variables. It should be emphasized that measurements on the following variables are currently, routinely obtained on each Army enlistee at locations shown during entrance processing:

- AFEES
  - Age
  - Height
  - CO test score
  - GM test score
  - Right eye acuity

- BT and AIT Stations
  - PT test score

The following variables are not routinely obtained at present: handedness, sports participation, smoking habits, arm length, eye color, M-70 tracking score performance. Although certain of the variables in the MVO and O models are currently measured and recorded on the enlistee's DA Form 20 and medical records, it is contemplated that model implementation will require additional recording of scores and physical measurements in accordance with a factored formula involving simple arithmetic calculations in algorithmic fashion. The format for this process is under review for final ARI approval.

ALTERNATIVES FOR MODEL IMPLEMENTATION:

General Considerations. Since the Army is estimated to require approximately 15,000 qualified personnel in MOS11B during FYs 1976-1981, this figure represents the gross number of enlistees which will have to be measured for consideration as potential TOW gunnery trainees. Although this figure may initially appear high and cost-ineffective, it also represents a baseline which will allow for maximization of initial model application. It is anticipated that once the placement model is validated (12-24 months), the number of MOS11B enlistees requiring placement model measurement could be reduced proportionally to a prescribed or sample of the total MOS11B population, and in direct relation to the annual Army TOW gunnery requirement. Although the primary alternative for most infantry trainees enlisting today is described as Route 2 in Table 1 of

Table 4

ARI MVO AND O MODEL

SOURCE OF DATA	MVO MODEL VARIABLES			
DA FORM 20 AND MEDICAL RECORD	AGE HEIGHT CO TEST SCORE GM TEST SCORE PT TEST SCORE RIGHT EYE ACUITY			
QUESTION/ RESPONSE		HANDEDNESS SPORTS PARTICIPATION SMOKING HABITS		
MEASUREMENT			ARM LENGTH EYE COLOR	
PERFORMANCE TEST				M-70 TRACKING SCORES 5 AND 25 MILLIRADIANS PER SECOND

O MODEL INCLUDES ALL VARIABLES IN MVO MODEL EXCEPT M-70 TRACKING SCORES.

Table 5

ESTIMATED TIME/COST OF OBTAINING

VARIABLES FOR MVO AND O MODELS

TIME TO OBTAIN (MIN)	DATA SOURCE/VARIABLE				ESTIMATED COST TO OBTAIN $
	DA FORM 20/ MEDICAL RECORDS	QUESTION/ RESPONSE	MEASUREMENT	M-70 TRACKING SCORE PERFORMANCE	
.25	AGE				.85
.25	HEIGHT				.85
.25	CO TEST SCORE				.85
.25	GM TEST SCORE				.85
.25	PT TEST SCORE				.85
.25	RIGHT EYE ACUITY				.85
.25		HANDEDNESS			
.50		SPORTS PARTICIPATION			1.70
.25		SMOKING HABITS			.85
.50			ARM LENGTH		1.70
.25			EYE COLOR		.85
6.66 (1)(3)				5/MRS(5)	(2)(3)
6.66 (1)(3)				25/MRS	(2)(3)
SUBTOTAL	1.5 min.	1 min.	.75 min.	13.32 min.	$11.05(4)
TOTAL: APPROXIMATELY 16.5 MINUTES PER TRAINEE.					

(1) Actual tracking time only (excludes administrative requirements such as movement to range site, pre-operational checks, etc.).
(2) Estimated at $79.00 per trainee at AFEES, $32.00 per trainee at AIT Station, (see Tables 8 and 9 for detailed costing).
(3) Exclude for O model
(4) Excludes cost of obtaining M-70 tracking score performance
(5) Milliradians per second.

this paper, application of the ARI placement model (MVO or O) could easily be implemented in Army field units prior to trainee attendance at local, unit TOW gunnery training courses. Crucial to the efficient implementation of the ARI model is identification of critical decision points in the training system where placement model measurements can be made cost-effectively. Additionally, it is especially vital to determine what variables, in the aggregate, constitute sufficient information necessary to make a GO-NO GO decision.

Although no formal considerations in the ARI model has been given to the "commander's evaluation" as a required variable, it is assumed that this criterion will remain as fundamental determinant in the decision process. It is a function which can be broadly or narrowly defined. That is, in the broad sense, any "commander" in charge of the enlistee/trainee at any point in the entrance or training process is capable of determining the GO-NO GO decision based upon measurement of the discriminate variables in the model and his subjective evaluation. A more narrow interpretation of this function would limit and reserve the "commander's evaluation" and the resulting decision to the trainee's AIT unit or field unit commander. Table 6 shows a diagram depicting crucial decision points which must be considered in the application of the ARI MVO model. Table 7 displays decision points for the O model.

MVO Model Implementation. Clearly, two alternatives present themselves as possibilities for MVO model implementation:

- o obtain all measurements, including the M-70 tracking scores, but less the PT test score, at the AFEES.
- o obtain all simplified measurements at the AFEES, the PT test score at BT/AIT, and the M-70 tracking scores plus the commander's evaluation during the last week(s) of AIT.

If the primary objective of model application is to assist personnel managers and commanders in identifying and "selecting-out" those enlistees not qualified to undergo TOW gunnery training, then the first alternative is considered to be optimal. However, this is certainly not the most cost-effective alternative. If, on the other hand, the main objective is to optimize the cost-effective alternative, allowing the total utilization of currently available resources, and considering the "real-world" necessity to consider the commander's evaluation, then the second, or multi-phased, alternative should be the preferred choice. Tables 8 and 9 show cost data associated with obtaining M-70 tracking scores for both alternatives within the implementation of the MVO model.

O Model Implementation. As displayed in Table 5, the only add-on costs associated with the measurement of O model variables are those incurred for transforming measurements routinely obtained in the enlistment process to an algorithmic scale, plus costs to measure and record handedness, sports participation, smoking habits, arm length, and eye color; all represent simple procedures, obtainable at minimal cost.

The primary consideration for the training manager, one which requires a key decision in both model interpretation and model implementation, is whether or not sufficient information is included in the O model to positively determine the individual's GO or NO GO status. If the answer to the above question is negative, the MVO model must be selected for implementation.

Table 6

MVO Model Decision Points

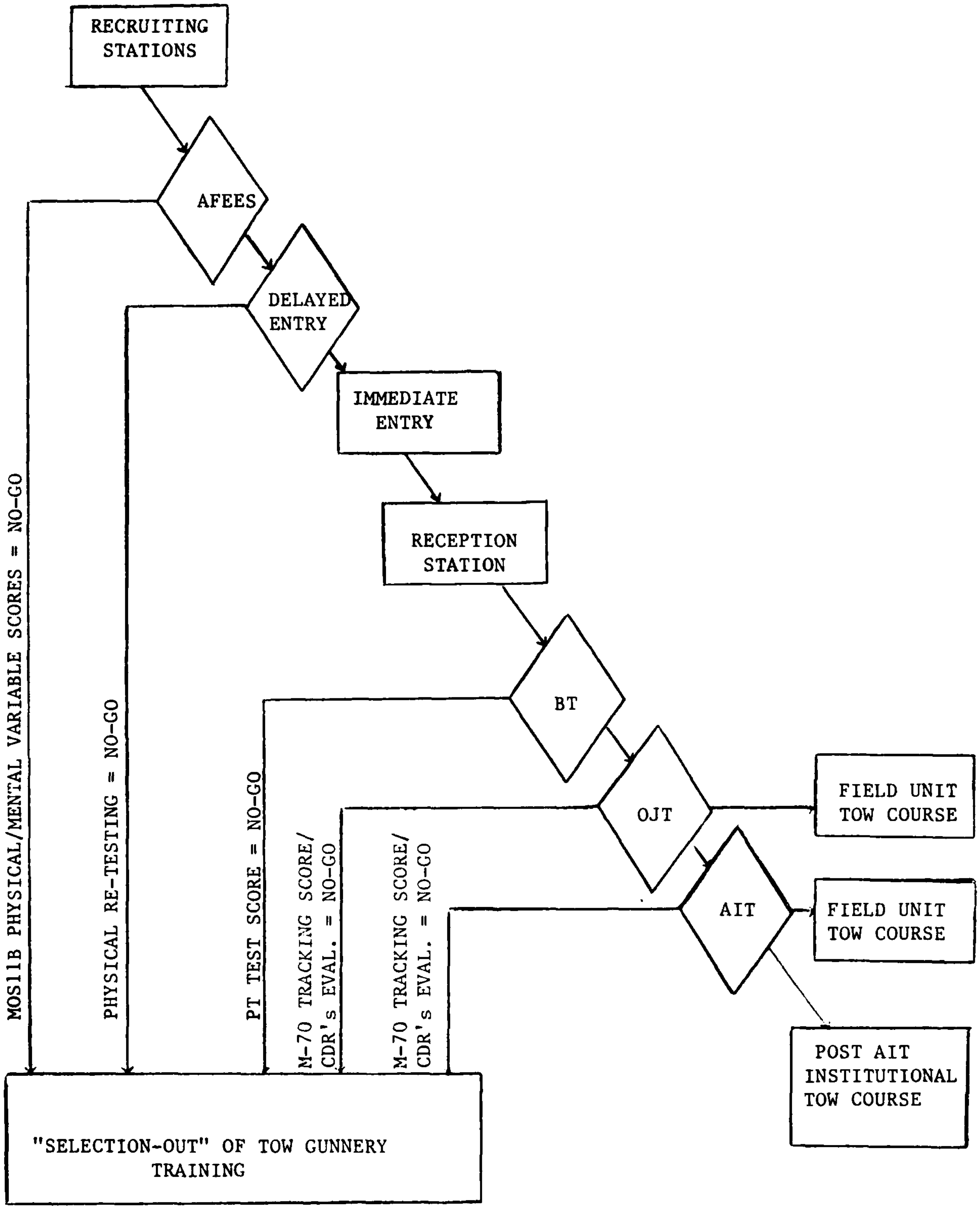

Table 7

O Model Decision Points

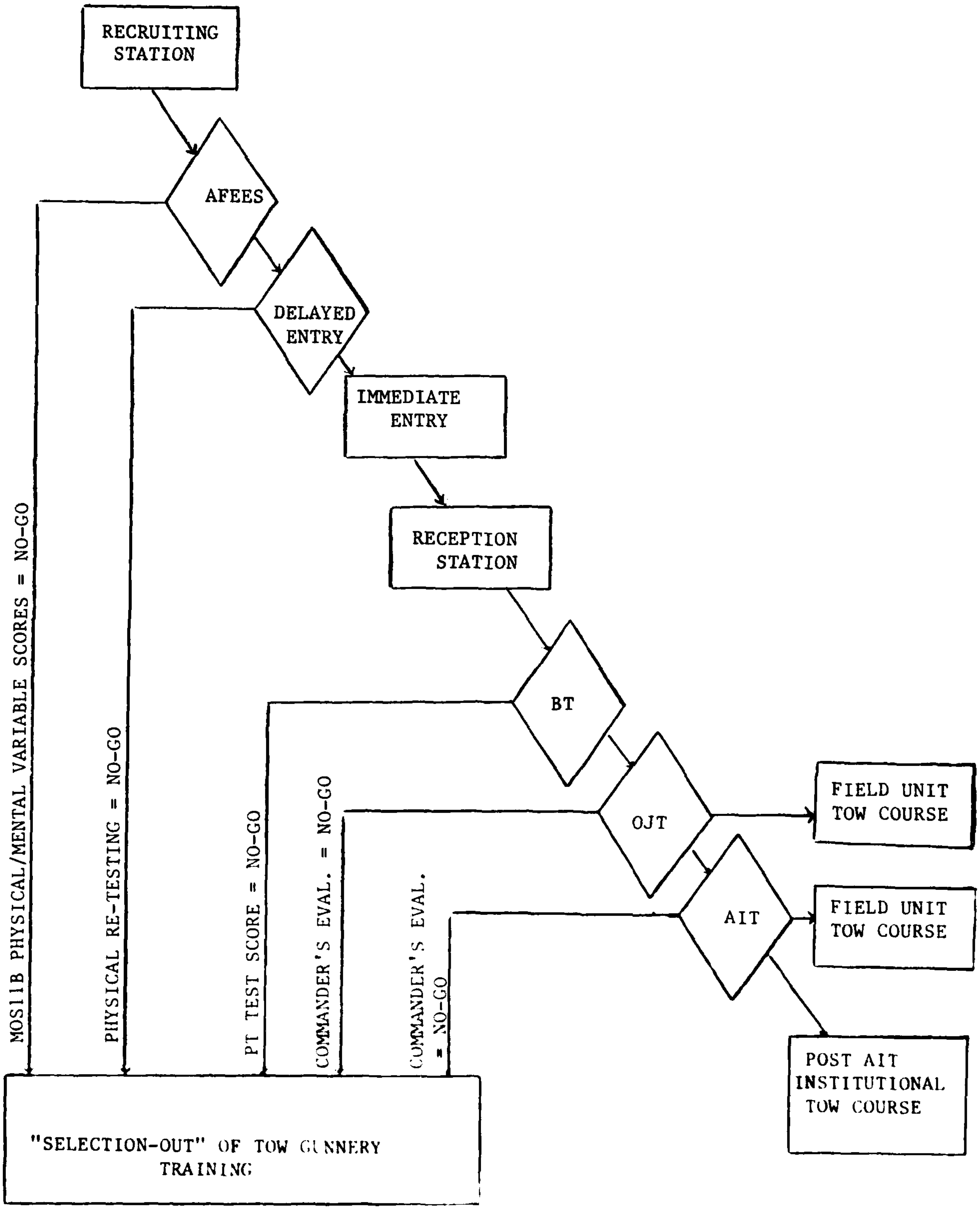

Table 8

ESTIMATED COST [1] OF OBTAINING M-70 TRACKING

SCORES FOR AN ARMY ENLISTEE AT AFEES

COST CATEGORY	OPERATIONS AND MAINTENANCE (ARMY) $	MILITARY PERSONNEL APPROPRIATION (ARMY) $	PROCUREMENT APPROPRIATION (ARMY) $
DIRECT COSTS			
EQUIPMENT (2) (CAPITAL COST)			21
EQUIPMENT MAINTENANCE	9		
AMMUNITION (3)			6
MISSION COSTS (4)	3	15	
ENLISTEE P&A (5)		5	
SUBTOTAL	12	20	27
DIRECT COSTS			
INSTALLATION OPERATIONS	4	6	
TRAINING AIDS	3	1	
OTHER	2	4	
SUBTOTAL	9	11	0

TOTAL/PER TRAINEE: $79

(1) Based upon measuring 15,000 enlistees annually identified as MOS11B qualified; inflated FY 1977 dollars.
(2) Considers 10 year straight-line amoritization of depreciation; includes cost of two TOW weapons with M-70 training sets and one 1/4 ton vehicle for mounting target.
(3) Blast simulators only.
(4) Includes administrative measurement costs.
(5) Applies only if enlistee is immediate entry (Grade E-1).

Table 9

ESTIMATED COST (1) OF OBTAINING M-70 TRACKING SCORES FOR AN ARMY TRAINEE AT AIT STATION WHERE TOW AND M-70 TRAINING SETS ARE COLLOCATED

COST CATEGORY	OPERATIONS AND MAINTENANCE (ARMY) $	MILITARY PERSONNEL APPROPRIATION (ARMY) $	PROCUREMENT APPROPRIATION (ARMY) $
DIRECT COSTS			
EQUIPMENT (2) (CAPITAL COST)			2
EQUIPMENT MAINTENANCE	1		
AMMUNITION (3)			6
MISSION COSTS	2	4	
ENLISTEE F&A (4)		3	
SUBTOTAL	3	7	8
INDIRECT COSTS			
INSTALLMENT OPERATIONS	4	1	
TRAINING AIDS	2	1	
OTHER	2	4	
SUBTOTAL	8	6	0

TOTAL/PER TRAINEE: $32

(1) Based upon measuring 15,000 trainees annually who are MOS11B qualified; inflated FY 1977 dollars.
(2) Considers 10 year straight-line amortization of depreciation; includes cost of one TOW weapon with M-70 training set and one ¼ ton vehicle for mounting target.
(3) Blast simulators only.
(4) Grade E-1.

Consideration for Model Selection and Implementation. If it is determined that the inclusion of the M-70 tracking scores associated with the MVO model is a key, a-priori discriminant variable, then the MVO model should be selected over the O model for implementation. The following rationales favor the assertain that the MVO model is the more favorable choice:

- simple measurement of physical and mental variables easily obtained at AFEES locations and B/AIT and units sites

- M-70 scores should provide a more positive, if not fundamental indicator as to the predictive proficiency of potential TOW gunners

- M-70 scores obtained at AIT sites which are collocated with the TOW weapon/M-70 training set and target vehicle will preclude capital investments for this equipment at AFEES

- retains flexibility in decision making process to accommodate need for commander's evaluation

Two options appear worthy of consideration for MVO model implementation. Both include the collection of the basic physical and mental data of the O model at AFEES and AIT/Unit sites, and the collection of M-70 tracking score data at either the AFEES or at AIT/Unit locations where the TOW weapon, M-70 training set and target vehicle are collocated.

If, on the other hand, it is concluded through a model validation process that the measurement of O model physical and mental variables alone are sufficient to predict gunner proficiency, then the O model would appear to represent the most efficient choice for the following reasons:

- measurement of variables easily obtained at AFEES locations and at BT/AIT and unit sites

- minimal cost to record and transcribe measurement data (estimated at $11.05 per trainee)

- no capital investment required for TOW weapon/M-70 training set and target vehicle at AFEES

- predicted proficiency of TOW gunners should result in reduction of attrition rates at institutional and unit TOW gunnery courses

- retains flexibility in decision making process to accommodate need for commander's evaluation

Table 10 shows a matrix which identifies various model implementation considerations.

Since the implementation of either model will involve some expenditure of funds (cost), it becomes necessary to determine which model is most cost-efficient. Clearly the model which requires the least investment of resources should represent the most cost effective option. However, only after determining the relative predictive proficiency impact of obtaining M-70 tracking scores, can this assertion be justified. The estimated relative costs associated with the implementation of the O model are far less than those of the MVO model, thereby increasing the cost per graduate at a proportionately smaller

Table 10

MODEL IMPLEMENTATION DATA

MODEL OPTIONS	IMPLEMENTATION CONSIDERATIONS				IMPACT ON EFFICIENCY				
	EASE OF OBTAINING DATA MEASUREMENTS	CAPITAL INVESTMENTS COST	MAXIMIZE PREDICTIVE PROFICIENCY	RETAIN CDRS EVALUATION REQUIREMENTS	DECREASE COST PER GRADUATE	DECREASE TOTAL TNG COST	REDUCE ATTRITION	INCREASE MATERIAL COST	INCREASE MAN-HOURS
O (ALL SITES)	✓			✓	✓	✓	✓		MARGINAL
MVO (AFEES)	✓	✓	✓	✓			✓	✓	✓
MVO (AIT/UNIT)	✓		✓	✓	✓	✓	✓		MARGINAL

rate. The percent of decrease in attrition required through O model implementation in order to absorb the investment cost is also relatively small.

The cost of implementing the MVO model at AFEES is comparatively large, as is the estimated revised cost per graduate. The estimated required percent of attrition reduction for this option is prohibitive and renders the implementation of the MVO model at AFEES as ineffective. Implementing the MVO model at AIT/Unit sites appears to represent a compromise alternative. Table 11 provides attrition and cost per TOW gunnery graduate data relative to the above discussion.

RECOMMENDED MODEL IMPLEMENTATION:

Assuming, at this time, that the M-70 tracking scores are key discriminant variables in model application, the MVO model is recommended for implementation in a two-phased process. Phase 1 should include the measurement, recording and algorithmic transcription of the following model variables at the AFEES:

age,

height,

CO Test Scores,

GM Test Scores,

right eye acuity,

handedness,

sports participation,

smoking habits,

arm length, and

Phase 2 should follow with the collection and transcription of the following variables at an AIT/Unit site where the TOW weapon/M-70 training set and target vehicle are collocated:

- PT test scores,
- M-70 tracking scores at 5 and 25 milliradians, and
- commander's evaluation rating

It it is determined, at some future point in time, that the O model represents sufficient information to make the GO-NO GO decision on an enlistee, the O model should be implemented.

CONCLUSIONS:

- Early determination of the impact of the M-70 tracking score upon model effectiveness and utlimately on predictive proficiency must be made
- O model is less costly to implement

Table 11

ATTRITION AND COST PER TOW GUNNERY GRADUATE

	CURRENT (1) FORECAST BASE COST PER GRADUATE AT 12% ATTRITION	DATA COLLECTION COSTS PER GRADUATE AT 12% ATTRITION $	NEW BASE COST PER GRADUATE AT 12% ATTRITION $	PERCENT ATTRITION	REDUCTION IN COST PER GRADUATE $	NEW COST PER GRADUATE $
O MODEL	737.	11.05	749(2)	11.0	6	743
				10.5	9	740(3)
				10.0	13	736
				9.5	16	733
				.		
				0.0	80	669
MVO MODEL AT AFEES	737.	90.05	827(2)	6.0	34	793
				3.0	57	770
				0.0	79	748(4)
MVO MODEL AT AIT/UNIT	737.	43.05	780(2)	10.0	9	771
				7.0	30	750
				5.5	40	740(3)
				3.0	58	722
				0.0	79	701

(1) Forecast base cost per TOW Gunnery Graduate of Fort Benning, GA, FY 1978-81; 1977 inflated dollars at 12% attrition rate; 1,500 graduates required.
(2) Rounded figure
(3) Break even point
(4) Cost ineffective alternative

- MVO model at AIT/Unit sites is less costly option over model at AFEES

- MVO model at AFEES is cost ineffective

- A pilot model validation test should be conducted to determine the predictive proficiency of the O versus the MVO model

- Both models should consider the retention of the commander's evaluation as a pre-selection requirement

Annex A
References

Department of the Army, Change 4, AR 611-201, Personnel Selection and Classification, Enlistment Career Management Fields and Military Occupational Specialties, Hq., Department of the Army, Washington, D. C., 9 June 1975.

Office of the Assistant Secretary of Defense (Manpower and Reserve Affairs), Military Manpower Training Report for FY 1978, OASD (M&RA), Washington, D. C., March 1977.

Swezey, Robert W.; Chitwood, Thomas E., Jr.; Easley, David I.; and Waite, Barbara J., Implications for TOW Gunnery Training Development, Volume I, Litton Mellonics, Springfield, Virginia, October 1977.

U.S. Army Infantry School, TOW System Evaluation, DEV Report No. 3, U.S. Army Infantry School, Fort Benning, Georgia, December 1976.

U.S. Army Training and Doctrine Command, Antiarmor System Study (A^2S^2) (Final Report) (U), U.S. Army Training and Doctrine Command, Fort Monroe, Virginia, December 1976 (CONFIDENTIAL).

Annex B

Attrition and Course Length: Their Effects on Cost Per Graduate and Cost Per Student Man-Year

Because student pay represents much of total training cost, the length of time it takes to teach a skill is important. Changes in course length are reflected differently in cost per student man-year and cost per graduate. For example, in halving the length of a course one halves the number of student man-years. If, at the same time, instructor costs and other support costs are proportionately reduced, the cost per student man-year remains the same while the cost per graduate is cut in half. If instructor costs and other support costs are reduced by less than a proportional amount (a more likely assumption), the cost per student man-year rises while the cost per graduate still declines.

Consider the following illustrative example. A Service has a requirement for 1200 graduates a year from a particular course. The course is taught with twelve classes a year with each class in session for one month. There are 104 students and 20 instructors for each class. Further, there are 52 support personnel devoted to the support of the course. In addition to supervisory personnel and school administrators, support personnel include those who operate and maintain equipment used in training and who run the housing, dining facilities, commissary, hospital, and other support activities. While these figures were chosen for their ease in illustrating a point, they are close to the actual student, instructor, and support manpower relationships in much enlisted training.

Assume, for the moment, that by eliminating some marginal course content and by using classroom time more efficiently, it is possible to reduce the length of each of these 12 courses from one month to 3/4 of a month. There are two hypothetical options:

- o teach the 12 classes in 9 months

- o reorganize into 16 classes of 75 students each, teaching year-around. Eliminate 1/4 of the instructor jobs, and 1/4 (or a smaller proportion) of the support jobs.

From: Office of the Assistant Secretary of Defense (Manpower and Reserve Affairs), Military Manpower Training Report for FY 1978, OASD (M&RA), Washington, D. C., March 1977.

It would be wasteful to have instructors teaching for only 9 months of the year. Spreading the teaching load over an entire year saves not only instructors but support personnel whose numbers should be related to the average number of students on the installation. (For simplicity, this example ignores annual leave which affects manpower requirements.)

The following table provides a look at the before and after details of the change assuming that the loads are spread over the entire year, and that support manpower is reduced in proportion to the student load reduction:

	Before	After
Graduates Per Year	1,200	1,200
Course Length	1 month	3/4 month
Classes Per Year	12	16
Students Per Class (also student man-years)	100	75
Instructors Per Class (also instructor man-years)	20	15
Support Personnel Per Class (also support man-years)	52	39
Total Man-Years	172	129

Because courses continue throughout the year, the annual student, instructor and support man-years equal the per-course figures above. Therefore, after the course-length reduction the school produces the same number of graduates with fewer instructors -- but the biggest savings come from student and support manpower. After the reduction the school is able to produce the 1200 graduates with the expenditure of only 129 man-years compared with 172 man-years before the change.

This example is useful to demonstrate how such a course-length reduction will affect the cost per graduate as well as the cost per student man-year. To simplify, the example deals only with manpower costs, assuming that all students cost $10,000 a man-year and that all instructors and support personnel cost $15,000 a man-year. The table below shows the cost per graduate and the cost per student man-year both before and after the course-length change:

	Before	After
Student Cost	$1,000,000	$750,000
Instructor Cost	300,000	125,000
Support Cost	780,000	585,000
Total Cost	2,080,000	1,560,000

Cost Per Graduate	1,733	1,300
Cost Per Student Man-Year	20,800	20,800

Despite the significant decrease in total cost and cost per graduate, the cost per student man-year shows no improvement. If one were to assess the change in efficiency of this organization solely on cost per student man-year he would come to the erroneous conclusion that there had been an increase in efficiency. This sample emphasizes the danger of basing judgments on a single element, particularly when that measure does not include an output element.

Cost per graduate and cost per student man-year yield even more divergent results when support reductions are less than proportionate to the student load reductions. Because there is a fixed component of supporting man-year, support reductions almost always occur at a lesser rate than student load reductions. Conversely, when student loads go up, support manpower goes up at a lesser rate.

The table below uses the previous example to show the effect on manpower if it is assumed that the 25% student load reduction generates only a 12.5% support reduction:

	Before	After
Graduates Per Year	1,200	1,200
Course Length	1 month	3/4 month
Classes Per Year	12	16
Students Per Class (also student man-years)	100	75
Instructors Per Class (also instructor man-years)	30	15
Support Personnel Per Class (also support man-years)	52	45
Total Man-years	172	135

In this case, the shortened course length saved only 37 man-years (172 less 135) compared with 43 man-years in the case of proportionate support reductions.

As the table below shows, when course length changes cause student man-year changes and, at the same time, support costs are reduced by less than a proportionate amount, cost per student man-year actually increase while cost per graduate decreases:

	Before	After
Student Cost	$1,000,000	$750,000
Instructor Cost	300,000	225,000

Support Cost	780,000	675,000
Total	2,080,000	1,650,000
Cost Per Graduate	1,733	1,375
Cost Per Student Man-Year	20,000	22,000

In this example the cost per graduate improves by $358 while the cost per student man-year actually worsens by $1,200.

Although attrition rates are dependent upon external factors such as the quality of student input to a course, the rates are an essential adjunct to analysis based upon cost per student man-year. A declining cost per student man-year is no bargain if it results from more and more students failing to complete their training successfully. Cost per graduate will reflect changes in costs due to changes in attrition rates; cost per student man-year may not.

The same example can be used to illustrate the effect attrition has on cost per graduate and cost per student man-year. Again, 12 one-month courses are taught with the objective of producing 1200 graduates a year. In the left-hand column below there is no attrition; all the other variables are the same as in the previous example. In the right-hand column it is assumed that 10 out of every 100 students who begin the course fail to complete it. It is further assumed that those who fail the course drop out at a constant rate over the duration of the course. Therefore, in order to produce 1200 graduates, 1320 students must begin the course each year. With the uniform rate of drop-out, the average number of students in a course rises to 105. The table below reflects the details of the course with and without attrition:

	No attrition	10% attrition
Graduates Per Year	1,200	1,200
Course Length	1 month	1 month
Classes Per Year	12	12
Students Per Class (Average) (also equals student man-years)	100	105
Instructor Per Class (also equals instructor man-years)	20	21
Support Personnel (also equals support man-years)	52	55
Total Man-years	172	181

The increase in average class size from 100 to 105 students warrants 1 additional instructor and about 3 additional support personnel (the precisely proportionate support increase would be 2.6 man-years).

The table below uses this example to show the effects of attrition both on

the cost per graduate and the cost per student man-year. Again, for simplicity the example deals only with manpower costs, assuming t at all students cost $10,000 a man-year and that instructors and support personnel all cost $15,000.

	No attrition	10% attrition
Student Cost	$1,000,000	$1,050,000
Instructor Cost	300,000	315,000
Support Cost	780,000	819,000 *
Total Cost	2,080,000	2,184,000
Cost Per Graduate	1,733	1,820
Cost Per Student Man-year	20,800	20,800

*Based upon 54.6 support personnel, an increase exactly proportionate to the student load increase from 100 to 105.

In this case, the increased attrition has no effect on the cost per student man-year, while the cost per graduate figure shows an increase, reflecting the cost of the additional resources that are required but do not increase the output.

Carrying through the previous alternate case where support costs change only at half the proportionate change in student load, the 10% attrition raises the cost per graduate to $1803 while the cost per student man-year actually declines to $20,614. Again, the cost per graduate figure reflects the increased efficiency while the cost per student man-year masks it.

Attrition rates are not necessarily good or bad. There is no optional percent. They are most necessary, however, as an adjunct to cost per student man-year analysis.